Network Redesign at Bates College

MTUG 2018

If the network is supposed to be up all of the time, then how do you maintain and upgrade it?

Bates College

"A private, highly selective, residential college devoted to undergraduate study in the liberal arts…"

5,526 applicants, 498 enrolled, including 43 from Maine in Freshman class

1,780 students, Maine is the 3rd most represented state

88% graduation rate

95% of first year students return for sophomore year

47% of students receive aid

100% of student need met

Bates College Campus

Network Topology - Before

Collapsed backbone

Layer 2 switching

Core distribution layer based on Juniper Virtual Chassis

Virtual Chassis made up of 5 ex4500 series switches across campus

Network Topology - After

Distributed backbone

Layer 3 routing

Core aggregation layer based on Juniper qfx5100 series switches across campus

Why Change?

ex4500 nearing end of life

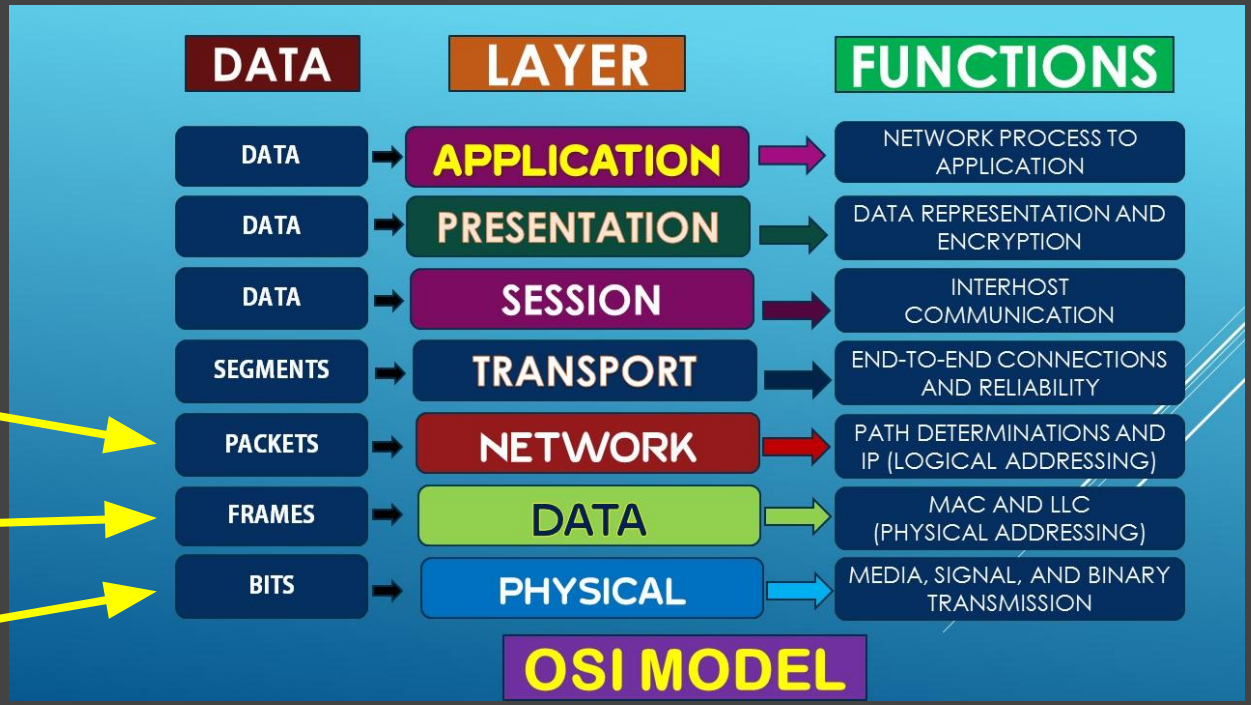
Increase network core speed from 10Gb

Redundant uplinks to avoid single points of failure

Easier upgrades to core software than on Virtual Chassis

Where do layers come from?

Developed by International Organization for Standardization (ISO) in the 1970s



Layer 3

Layer 2

Layer 1

Source: http://www.zeronetwork.co.in/2015/06/osi-model.html

Layer 0 - Bates campus

133 acres in Lewiston, Maine

Some buildings were built before the college founding in 1855

Continuous renovation and new construction

Buried conduit for data and phone cables connects all major buildings and most others

Some with generator backup

Layer 1 - Fiber Network

62.5 micron multi-mode from 1990s: 220 meters, 1 Gigabit

50 micron multi-mode from 2000s: 300 meters, 1-10 Gigabit

9 micron single-mode from mid-2000s: 40,000 meters 1-10-40 Gigabit

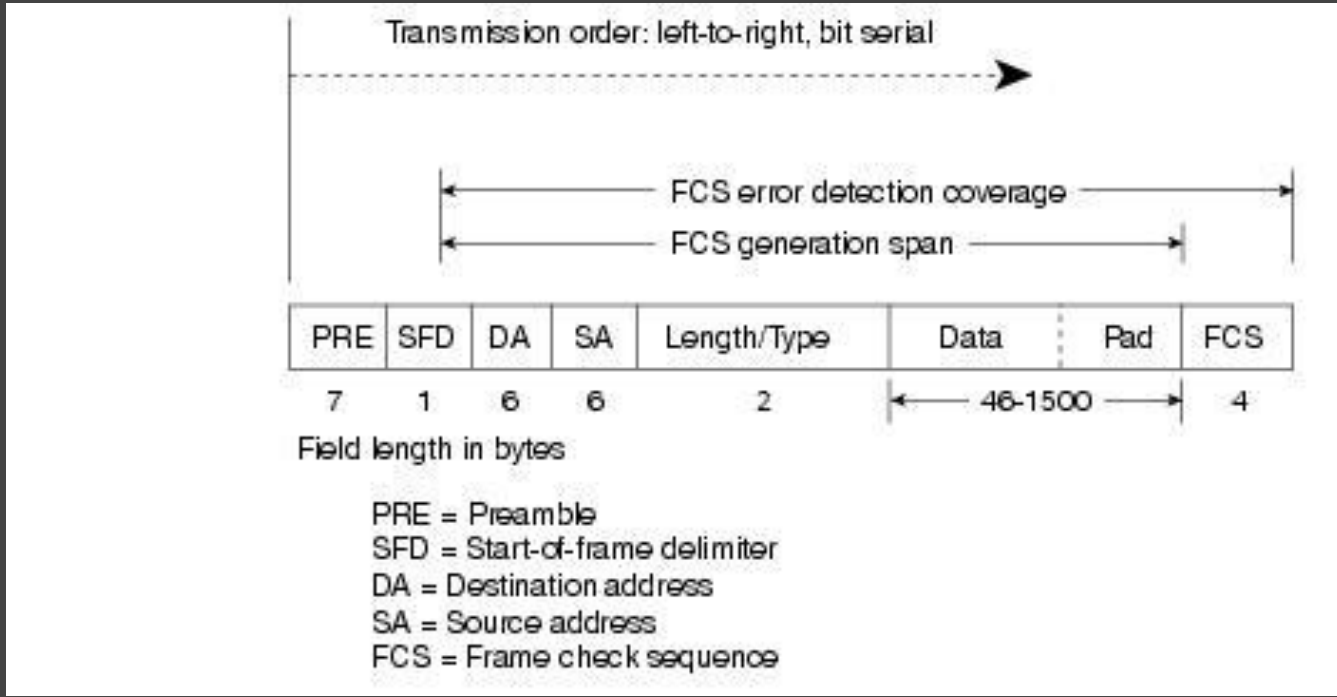
Layer 2 - Ethernet Frame

Created by DEC, Intel, and Xerox in 1970s

Media Access Control

MAC Address

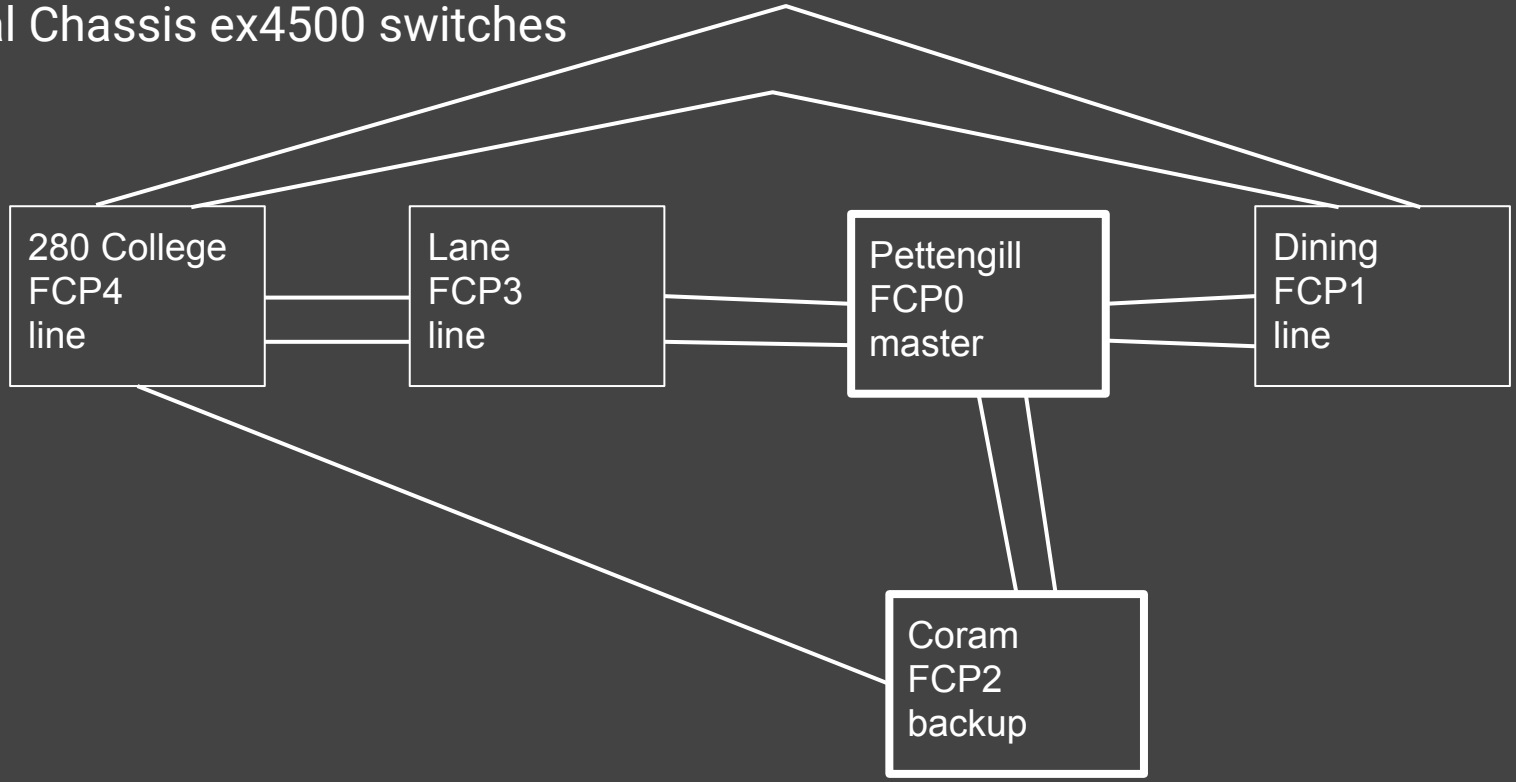
48 bits - 6 bytes
00:00:00:00:00:00
ff:ff:ff:ff:ff:ff



Source: http://docwiki.cisco.com/wiki/Ethernet_Technologies

Layer 2 - Network Core

Juniper Virtual Chassis ex4500 switches



Juniper Junos

switch / router OS based on NetBSD

CLI via serial console or SSH

GUI via web browser

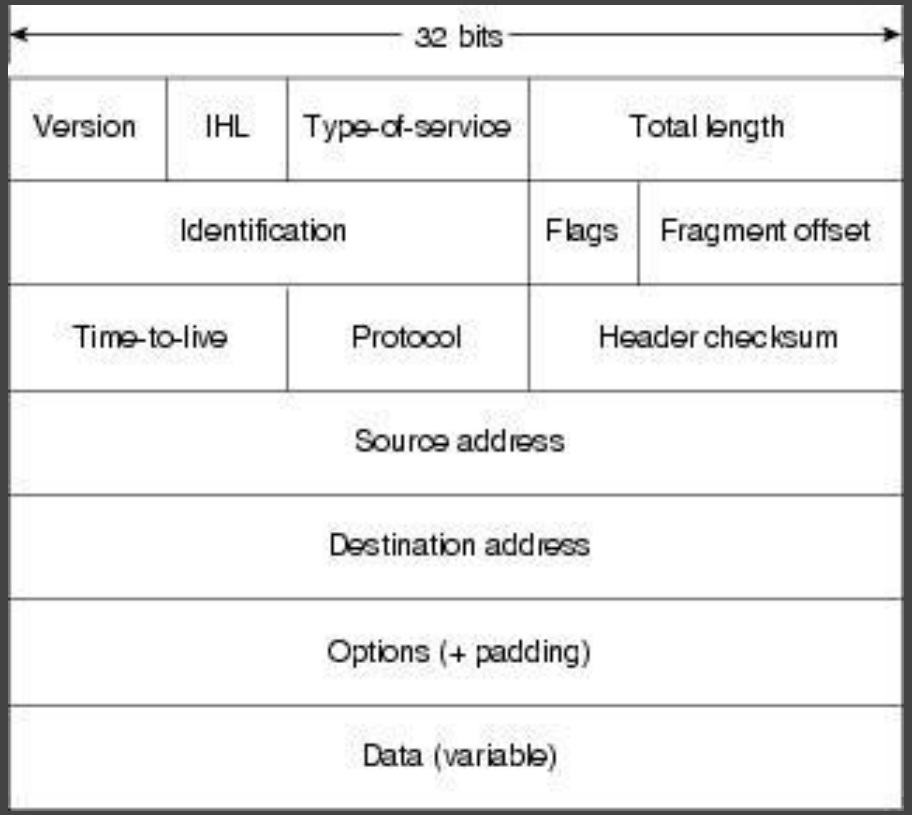
Layer 3 - IP Packet

Invented by Vint Cerf and Bob Kahn in the 1970s

IP address (v4)
32 bits

134.181.139.37

“dotted quad”
0-255



Source:

Maintaining Reliability

Regular software upgrades - PM

Regular hardware upgrades - EOL, BYOD

Control and Data Planes for online changes

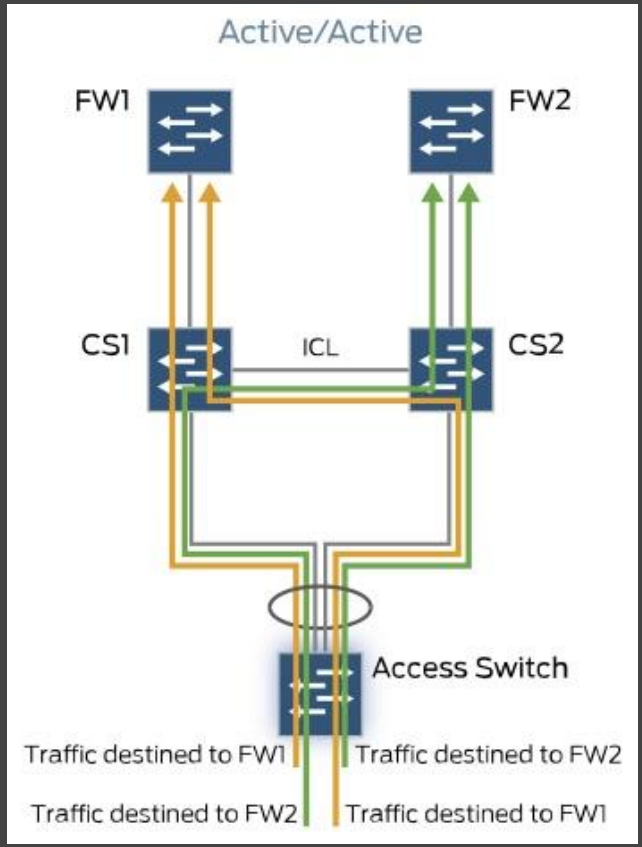
Juniper and Cisco options for fallback (confirm, rollback and reboot)

Multi-Chassis LAG

Juniper MC-LAG

Cisco Virtual PortChannel

Cisco Multichassis Etherchannel



Source: Juniper nce-143-mid-size-enterprise-campus-solution.pdf

Layer 2 - Spanning Tree

Redundant links but not all are used

Convergence

Avoid spanning tree with VC, LAG, or L3

Options

MC-LAG - SP focus, complicated, not on all hardware models

RTG - still unused links, just rapid convergence

L3 at buildings - diverse paths, easy to upgrade or replace a device

L3 issues

Some devices still require L2 connectivity across campus

EVPN / VXLAN

Can’t have L2 and L3 on the same interface

Need a routing protocol

IP addressing changes

L3 implementation

Reconfigure the distribution and access switches in a building
- ex4200 - adds routing to previous switching role
- ex2200 - change VLANs and management configuration

Add 2nd link for L2 network

Update DHCP servers

Update DNS servers

Add OSPF routing protocol

Routing Protocols

Static
RIP
OSPF
BGP
    iBGP
    eBGP

OSPF history

Open Shortest Path First
Link-State
Developed in 1991 by John Moy

OSPF handshake

3 way handshake ensures bi-directional connectivity

OSPF priority

Designated router

OSPF route injection

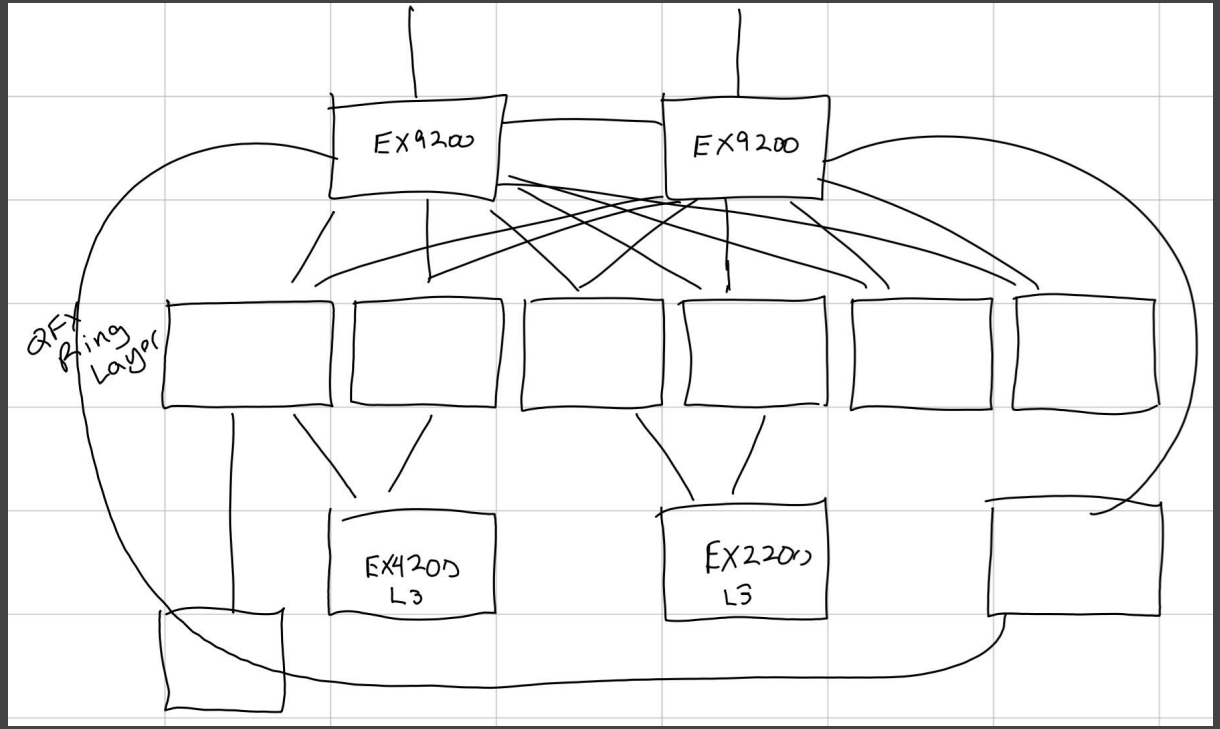
OSPF metrics

OSPF guidelines

L3 at Building Switches

No spanning tree convergence issue

Diverse paths



L3 Implementation at Bates

PM opportunities
Minimize disruption to academic activities

First Approach
- Do everything at one time

Second Approach
- Parallel installation in a building to allow phases

Operational Issues

DHCP
- Protocol handshake
- Helper / Relay

MAC-IP binding
- L2 forwarding
- L3 routing

ARP

Operational Issues

- Computers
  - Macs
  - Windows
  - Linux
- Printers
- Audio-Visual equipment
- Security - cameras, etc.
- Building Automation equipment

Future Projects at Bates

Multi-Rate switches for increased AP bandwidth

Data Center Interconnect

Juniper MC-LAG

Juniper VXLAN

Bates

Vendor Partners:

Juniper, Jason Rioux, Systems Engineer

Bates College, Information and Library Services, Network and Infrastructure Services:

Jim Bauer, Director

Rob Spellman, Associate Director for Network Services

Kevin Poland, Network Infrastructure Project Manager

Ryan Odom, Network Infrastructure Project Manager

Karen McArthur, System Administrator

Bruce Hall, Network Administrator

Future MTUG Topics?

Cable management (over time and at scale, documentation, labeling)

Network Monitoring

Network Management and Automation

802.1X Network Access Control

Emerging standards for 2.5Gb and 5Gb on copper


BATES